

# **INDOOR AIR QUALITY ASSESSMENT**

**Greenfield Public Library  
402 Main Street  
Greenfield, Massachusetts**



Prepared by:  
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Bureau of Environmental Health Assessment  
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## **Background/Introduction**

At the request of Lisa Hebert of the Greenfield Board of Health, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at the Greenfield Public Library, 402 Main Street, Greenfield, Massachusetts. Reports from building occupants of indoor air quality related symptoms prompted this request. On August 13, 2001, a visit was made to this school by Michael Feeney, Chief of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air quality assessment.

The library contains two wings in a split-level configuration. The original wing was a free standing, two-story, wood frame mansion constructed in 1797 (see Picture 1). A two-story brick wing was added to the rear of the building in the 1950s. The library occupies the first floor of the 1797 wing and the second floor of the 1950s wing. The second floor of the 1797 wing is used for administrative offices. The ground floor of the 1950s wing contains a conference room, an office and restrooms. The basement of the 1797 wing is used for storage of books and contains a mechanical room and the custodial office. An elevator shaft services each floor of the 1797 wing. Windows are sash windows that are not openable. The library exhaust ventilation was renovated in 1998 (MJA & KL, 1998). Exhaust vents were removed and new motors were added to the basement and first floor.

## **Methods**

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak <sup>TM</sup>, IAQ Monitor Model 8551. Water content of carpeting was measured

with a Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe. Moisture measurements were taken in the basement conference room.

## **Results**

The library has a staff of 10 and is used by 100+ members of the public daily. Tests were taken during normal operations at the library and results appear in Tables 1-2.

## **Discussion**

### **Ventilation**

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million of air (ppm) in 16 of 18 areas surveyed, indicating a ventilation problem in most areas. It is also noted that a number of areas were sparsely populated during the assessment. Under ordinary circumstances, low population in areas of the building would be expected to greatly reduce carbon dioxide levels.

Fresh air is supplied by a unit ventilator (univent) system ([see Figure 1](#)). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit. Fresh and return air are mixed, filtered, heated and provided to rooms through an air diffuser located in the top of the unit. Univents were functioning in the majority of areas examined.

Exhaust ventilation is provided by ceiling-mounted exhaust vents in the first floor library areas. The basement conference room has a wall-mounted exhaust vent, which is connected to a large fan installed on the rear exterior wall (see Picture 2). In all areas examined, exhaust vents were deactivated. Without a functional exhaust system,

normally occurring environmental pollutants can build-up and lead to indoor air quality complaints.

The administrative offices on the second floor do not have mechanical exhaust ventilation. The roof of the 1797 wing has two chimney-like structures, which appear to be exhaust ventilation airshafts. A large grill in the staff office appears to be connected to the western brick ventilation shaft by ductwork (see Picture 3) in the attic. A second large grill located at the top of the stairwell from the first floor may also be connected to the eastern brick ventilation shaft. The sound of vehicle traffic was noted emanating from this grill, indicating the airshaft is likely open to the outdoors. These vents are not mechanical, but use rising, heated air to draw environmental pollutants from the building. While this system can work well during the heating season to provide exhaust ventilation, the system does not work during the air-conditioning season. These vents may also serve as a moisture source during summer weather. Additionally, a number of areas in the basement do not have mechanical fresh air supply systems (see Tables).

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of building occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last servicing and balancing was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that

the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings ranged from 71° F to 76° F, which were within the BEHA recommended comfort guidelines in all areas measured. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity was measured in a range of 46 to 59 percent (with the exception of the basement conference room, which measured 70 percent), which were also within the BEHA recommended comfort range in all areas sampled. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

### **Microbial/Moisture Concerns**

Of note was the conference room on the ground floor of the 1950s wing, which had a relative humidity measurement of 70 percent. Prolonged relative humidity concentrations indoors above 70 percent can foster mold growth in susceptible materials (ASHRAE, 1989) such as carpeting, cardboard, paper, books, cloth and other materials. Porous materials, if repeatedly exposed to high humidity, can serve as mold growth media. A musty odor was perceived upon entering this room.

In order to ascertain whether carpet was dampened by high relative humidity, moisture sampling was done in the carpeting. Most areas of carpeting had moisture content measurements of 8.8 to 33.2 percent, indicating that the carpet was indeed moistened. Two factors may be contributing to the moistening of the carpet: operation/non operation of different components of the ventilation system and/or water penetration through the exterior wall of this wing of the GPL. During the assessment, the univent in this room was operating and the exhaust vent fan was deactivated. Under these conditions, water vapor introduced into this area of the building from outdoors by the univent can build up, since the exhaust vent is not removing air from the space. This

condition is extremely problematic when outdoor relative humidity is high (on this day, 91 percent). While the operation of the univent will remove some moisture from air passing through cooling coils, extreme relative humidity conditions outdoors can introduce excess moisture into the indoor environment. This excess moisture can then be absorbed by building components, particularly carpeting.

The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that carpeting be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If carpets are not dried within this time frame, mold growth may occur. Water-damaged carpeting cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy carpeting is not recommended.

Moisture introduction into the basement can also be problematic for the books stored in the basement stacks. Paper and book binding materials can support mold growth if chronically exposed to water vapor. Control of moisture/water penetration is necessary to prevent microbial growth.

A second possible means for introducing moisture into the basement area is chronic moistening of the rear exterior wall from a combination of a lack of a gutter/downspout system for the roof and the existence of clinging ivy on the rear wall. Water damage to the foundation wall (see Picture 4), brick support pillars (see Picture 5) and a basement stairwell (see Picture 6) in contact with the wall itself, indicate signs of chronic water penetration. During the course of the assessment, a thunderstorm producing a heavy rainfall occurred. This rainfall allowed Mr. Feeney to observe water drainage around the exterior of the building. The lack of a gutter/downspout system allows back-splashing rainwater to impact on the ground adjacent to the exterior wall, which results in chronic wetting. This condition allows water to pool against the building's exterior wall and foundation (see Picture 7). Gutters and downspouts should

be designed to direct rainwater away from the base of the building to prevent the chronic wetting of exterior walls which can result in damaged brickwork and/or mold growth.

Another source of moisture penetration into the building may be through the rear exterior wall, which was formerly covered with a substantial ivy growth (see Picture 8). Clinging plants can cause water damage to brickwork by inserting tendrils into brick and mortar. Water can penetrate into the brick along the tendrils, which can subsequently freeze and thaw during the winter. This freezing/thawing action can weaken bricks and mortar, resulting in damage to the wall. In addition, the growth of roots against the exterior walls can bring moisture in contact with wall brick and eventually lead to cracks and/or fissures in the foundation/slab below ground level. Over time, this process can undermine the integrity of the building envelope and provide a means of water entry into the building via capillary action through foundation concrete and masonry (Lstiburek, J. & Brennan, T.; 2001). In order to avoid this problem, clinging plants on brickwork is not recommended.

During the course of the evaluation, accumulated water was observed on the surface of univent fresh air diffusers. This condition can indicate the uncontrolled introduction of moisture into the interior of the building. Two exhaust vents exist on the second floor of the building that belong to a former ventilation system. As mentioned previously, the exhaust vent in the second floor office is connected by ductwork to a chimney-like structure. The connection of the other exhaust vent could not be determined, however as discussed, outdoor noises such as passing traffic were heard in the airshaft indicating that this vent is likely open to the outdoors. Each of these vents corresponds to chimney-like structures on the roof of the 1797 wing (see Picture 9). These vents can be a source of moisture being introduced into the building, resulting in excessive production of condensation.



Condensation is generated under the following conditions. When warm, moist air passes over a surface that is colder than the air, water condensation can collect on the cold surface. Over time, water droplets can form, which can then drip from a suspended cold surface. For this reason, HVAC systems are equipped with drainage systems beneath cooling coils to drain condensate as moist outdoor air is cooled. Univents have drain (drip) pans that are connected to a drainage pipe system. Each of these drip pans empty through a PVC pipe that exits through the exterior wall clapboard (see Picture 10). Each of these pipes drain condensation directly onto the exterior wall, resulting in chronic moistening that is rotting the clapboard. This chronic moistening can result in water penetration into the interior of the building.

Several rooms contained a number of plants, some of which were located on top of univents. Plant soil and drip pans can also provide a source of mold growth. Over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth. Plants should have drip pans to prevent wetting and subsequent mold colonization of window frames. Plants should also be located away from univents and exhaust ventilation to prevent the aerosolization of mold, dirt and pollen.

A water fountain was observed above carpeting in the children's section (see Picture 11). Spills from the water fountain can result in wetting of the carpet, which can lead to mold growth.

### **Other Concerns**

Cleaning products, label remover and other materials were found in the staff office. Many of these products contain chemicals, which can be irritating to the eyes, nose and throat. These products should be stored properly and used in an area with proper exhaust ventilation to remove odors.

The staff work office contained a photocopier. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). Library personnel should ensure that local exhaust ventilation is activated while equipment is in use to help reduce excess heat and odors in this area.

## **Conclusions/Recommendations**

Occupant symptoms and complaints are consistent with what might be expected in an environment with a poorly operating ventilation system and chronic moisture penetration into the basement. The conditions observed in the GPL raise several issues. The combination of the building design, maintenance, work hygiene practices and the condition of stored materials in the building can have an adverse impact on indoor air quality. No exhaust ventilation exists in the book stack area of the basement. Without exhaust ventilation, water vapor can build up and linger in the basement. Water vapor penetration through the foundation walls must be halted in order to prevent further mold colonization of the library book collection in the basement stacks. However, this remedy does not solve the issue of lack of mechanical exhaust ventilation for the basement, which should decrease the overall water vapor load for the building.

As an initial step, options concerning the preservation of materials stored in this area should be considered. Since many books are stored in this area, an evaluation concerning disposition of these materials must be made. Porous materials that are judged not worthy of preservation, restoration or transfer to another media (e.g., microfiche or computer scanning) should be discarded. Where stored materials are to be preserved, restored or otherwise handled, an evaluation should be done by a professional

book/records conservator. This process can be rather expensive, and may be considered for conservation of irreplaceable documents that are colonized with mold. Due to cost of book conservation, disposal or replacement of moldy materials may be the most economically feasible option.

For these reasons a two-phase approach to correcting IAQ problems is required, consisting of immediate (**short-term**) measures to improve air quality and **long-term** measures that will require planning and resources to adequately address overall indoor air quality concerns.

The following **short-term** measures should be considered for immediate implementation:

1. Consider removing any water damaged carpeting from the basement conference room. Disinfect non-porous surfaces with an appropriate antimicrobial compound. After disinfection, clean non-porous surfaces with soap and water.
2. Consider replacing carpeting in the basement conference room with tile or other non-porous surface.
3. Temporarily seal the original exhaust vents above the second floor stairwell with polyethylene plastic and duct tape until a permanent seal can be erected.
4. Consider using a floor fan set on the lowest setting to direct air into the exhaust vent in the staff office.
5. Consider consulting a professional book/records conservator to obtain guidance concerning the proper methods for preserving the stored materials in the 1797 building basement.
6. Examine other porous materials for mold growth and musty odors. If present, discard these materials.
7. Extend condensation drains to empty at ground level.

8. Operate the basement conference room exhaust ventilation fan when the univent is operating to remove water vapor.
9. Survey all univent functions to ascertain if an adequate air supply exists for each room and make univent repairs as needed. Check fresh air intakes for repair and increase the percentage of fresh air intake if necessary. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers building-wide.
10. To maximize air exchange, the BEHA recommends that mechanical ventilation operate continuously during periods of occupancy, independent of thermostat control.
11. Continue to remove clinging ivy from the exterior walls of the GPL.
12. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
13. Move plants away from univents. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.
14. Use cleaning and other supplies with adequate ventilation. Obtain Material Safety Data Sheets (MSDS) for cleaning products from manufacturers or suppliers. Maintain these MSDS and train individuals in the proper use, storage and

protective measures for each material in a manner consistent with the Massachusetts Right-To-Know Law, M.G.L. c. 111F (MGL, 1983)

The following **long-term measures** should be considered:

1. Examine the feasibility of providing mechanical exhaust ventilation for the basement book stacks and the second floor offices. For the second floor offices with univents, examine the feasibility of converting the existing airshafts of the original ventilation system into mechanical systems. Contact an HVAC engineering firm to determine if existing vents, ductwork, etc. can be retrofitted for mechanical ventilation.
2. Install a gutter/downspout system to properly drain rainwater away from the foundation
3. Repair roof and replace/repair any water-stained ceiling tiles and wall plaster. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial if necessary.

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**Picture 1**



**Wood Frame Mansion Constructed In 1797**

**Picture 2**



**Exhaust Fan for Basement Meeting Room**



**Picture 3**



**Ductwork in Attic Connected to the Western Brick Ventilation Shaft**

**Picture 4**



**Water Damage to Foundation Wall**

**Picture 5**



**Water Damage to Brick Support Pillars**

**Picture 6**



**Water Damage to Basement Stairwell and Foundation Wall**

**Picture 7**



**Pooling Rainwater from Roof, Note Damage to Foundation Stone in Proximity to  
Pool**

**Picture 8**



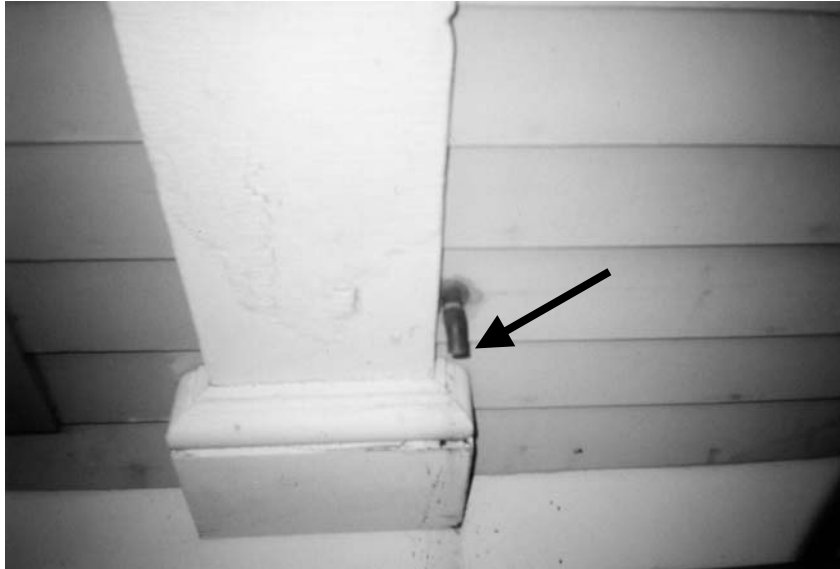
**Exterior Wall at Rear of Building Formerly Covered With Substantial Ivy Growth**

**Picture 9**



**Chimney-Like Structures on the Roof Of the 1797 Wing**

**Picture 10**



**Condensation Drain Emptying Onto Exterior Wall Clapboard,  
Note Damage to Wood below Drain**



**Picture 11**



**Water Fountain Observed Above Carpeting in the Children's Section**

TABLE 1

**Indoor Air Test Results – Greenfield Public Library, Greenfield, MA – August 10, 2001**

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	393	82	91					Measurements taken @ 1:45 pm
Director's Office	806	71	59	1	No	Yes (1)	No	Fireplace, univent-condensation on louver, door open
Staff Office	782	74	59	3	No	Yes (2)	No	univent-condensation on louver, door open
Staff Office-Printer	802	76	53	1	No	Yes (1)	No	Door open
Kitchen	781	74	62	0	No	Yes (1)	No	Door open
Restroom					No	No	Yes	Exhaust vent broken
Reference Area	1203	72	50	3	No	Yes (2)	No	Fireplace
Computer Area	1209	72	49	7	No	Yes (1)	No	univent-condensation on louver
Front Desk Area	1229	72	50	4	No	Yes (1)	No	univent-condensation on louver
Elevator Stack Area	1081	73	52	3	Yes	Yes (1)	Yes	Exhaust off
Rear Stack	835	74	54	1	Yes	Yes (2)	No	

\* ppm = parts per million parts of air  
CT = ceiling tiles

**Comfort Guidelines**

Carbon Dioxide - < 600 ppm = preferred  
600 - 800 ppm = acceptable  
> 800 ppm = indicative of ventilation problems  
Temperature - 70 - 78 °F  
Relative Humidity - 40 - 60%

TABLE 2

**Indoor Air Test Results – Greenfield Public Library, Greenfield, MA – August 10, 2001**

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Child Library Room	1007	71	49	4	No	Yes (3)	Yes	Exhaust off, univent-condensation on louver, fireplace, water bubbler over carpet, plants, door open
Child Library Inner Room	1138	73	46	1	No	Yes (1)	No	
Greenfield Room	1301	73	56	2	No	Yes (1)	Yes	Exhaust off, musty odor
Elevator Car	1168	73	54	1	No	No	No	
Conference Room	530	74	70	0	No	Yes	Yes	Exhaust off, musty odor – carpet moisture – 8.8%-33.2%
Stack Room	946	75	56	0	No	No	No	Pillars-efflorescence, water damage-outer wall-mold
Children's Library	1175	75	49	0	No	Yes	No	Supply off
Children's Library Closet						No	Yes	Water damaged plaster
Children's Library Restroom						No	Yes	No undercut door
Front Desk Area	1389	73	53	17	Yes	Yes	No	Taken @ 3:05 pm

\* ppm = parts per million parts of air  
CT = ceiling tiles

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Temperature - 70 - 78 °F  
Relative Humidity - 40 - 60%